Agroforestry that will advance rural development

*Agroforestry was one of the buzz words of 2017, with a highlight being the Agroforestry 2017 conference at Cranfield in June attended by around 250 people including 130 farmers and foresters (see Issue 122 for a report on the event). This year also marked the end of our four-year European research project AGFORWARD, or AGroFORestry that Will Advance Rural Development. Agroforestry researcher **Jo Smith** looks back on what's been achieved in this project, the first for ORC to focus solely on agroforestry.*

How much agroforestry is there in Europe?

One of the key objectives of AGFORWARD was to understand the context and extent of agroforestry systems in Europe, a task which was a lot more complicated than it seemed at first sight. Land classification systems often don't pick up the differences between agriculture, agroforestry and forestry. Information on the extent of agroforestry in Europe is essential for the development of supporting policies; the fact that this information doesn't already exist reflects the difficulties of defining what agroforestry is (and isn't). A team led by Michael den Herder at the European Forestry Institute in Finland used the Land Use and Land Cover survey data from Eurostat, and used three main agroforestry categories based on the main farming focus and components: arable agroforestry, livestock agroforestry and high value tree agroforestry, with some overlap between the categories (high value tree agroforestry can include either arable or livestock components). In total, the team estimated that agroforestry in the EU 27 covers about 15.4 million ha (3.6% of territorial area and 8.8% of the utilised agricultural area (UAA))[1]. Of this, livestock agroforestry is the dominant system, covering 15.1 million ha, with the largest areas in Greece, Spain, France, Italy and Portugal. High value tree agroforestry covers 1.1 million ha, again with a focus in the Mediterranean countries. Silvoarable systems cover just 0.3 million ha with the dominant system combining arable crops with olive trees (109,000 ha). In the UK, agroforestry covers just 3.3% of the UAA with livestock agroforestry being the dominant type. Considering the many benefits that integrating trees and agriculture can bring with regard to balancing productivity with protection of the environment, there is a real need to look at how we can encourage uptake of agroforestry through better support mechanisms, knowledge exchange and skill-building.

Working with agroforestry farmers

At the heart of the project has been a network of 42 groups involving 665 agroforestry stakeholders who, in collaboration with the research institutes, have been developing and then field-testing innovations to improve their agroforestry systems. These have included farmers of traditional agroforestry systems such as the beautiful cork oak landscapes in Portugal and Spain, the bocage hedgerows in northern France, and wood pastures in Hungary, UK, Romania and Sweden; farmers of high value tree systems interested in introducing grazing or intercropping, including olive orchards in Italy and Greece, and grazed apple orchards in France and the UK; arable farmers in Spain, France, Italy, Greece, Germany and the UK; and pig, poultry and ruminant livestock farmers in the Netherlands, France, Italy, Spain, Denmark and the UK. The innovations trialled were really diverse, ranging from introducing free range and organic chickens into commercial apple orchards in the Netherlands to growing wild asparagus in olive orchards, to trialling 'invisible fencing' to control cattle movement in UK wood pasture systems, to investigating the establishment of valuable timber trees on arable land in Switzerland. More information on the different groups and trials can be found on www.agforward.eu. A key output from these various trials are a suite of 'innovation leaflets' which can be found at www.train.agforward.eu. In the UK, we worked with two stakeholder groups – silvoarable and silvopastoral farmers – which led to four on-farm trials. The silvoarable stakeholders identified two innovations to investigate — developing agroforestry-adapted cereals, which we trialled at Wakelyns Agroforestry (Box 4), and managing the tree understorey as a productive part of the system, which we explored with Iain Tolhurst at Tolhurst Organic CIC (Box 1). The silvopastoral stakeholders identified the development of shade tolerant understorey swards in woodland eggs/chickens as an innovation, and the value of tree fodder as an area that needed more investigation. We worked with the silvopoultry trial site at FAI Farms in Oxford to test and compare three sward mixtures from establishment to introduction of the chickens (Box 2), and on our own farm, carried out a pilot project on tree fodder (Box 3).

AGFORWARD

The Agforward project brought together a truly multi-disciplinary and international team of researchers with a common aim of promoting agroforestry practices in Europe that will advance rural development through improved competitiveness, and social and environmental enhancement. The project involved two international agroforestry institutions and over 23 universities, research and farming organisations from across Europe, and was coordinated by Dr Paul Burgess and his colleagues at Cranfield University in the UK.

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Agroforestry policy

A recognised barrier to greater uptake of agroforestry has been a lack of policy support, particularly in the UK where agroforestry has fallen through the gaps between agricultural and forestry policies. A review of policies relating to agroforestry in its broadest sense was carried out by a team led by Rosa Mosquero-Losada at the University of Santiago[2]. This report highlighted previous problems with European policies which set a threshold of 50 trees/ha above which farmers risked losing their direct payments (Pillar 1 of the 2017-2013 CAP); this threshold increased to 100 trees/ha in the current CAP but there is still confusion about how this is implemented in the different member states.

Within Pillar 2 (the Rural Development Programme), the review identified 27 measures that can benefit or support agroforestry systems, including measures to support forest understorey grazing to reduce fire risks, forest farming, hedgerows and forest strips in arable lands or grazing in orchards[2]. The specific agroforestry measure (Measure 222 in CAP 2007-2013 and sub-measure 8.2 in CAP 2014-2020) supports the establishment (and management in CAP 2014-2020) has been implemented in only a limited number of RDP programmes (10 RDPs in CAP 2007-2013 and 12 RDPs in CAP 2014-2020). We have identified 15 recommendations to improve policy support for agroforestry in Europe[3]. One of the more innovative recommendations is the introduction of an 'agroforestry option' within each of the three categories of land use in Pillar 1 (arable land, permanent pasture and permanent crops), to be self-declared by the farmer, and supported by the submission of a management plan. This would ensure that agroforestry farmers maintain their eligibility for direct payments, one of the key barriers to agroforestry uptake in previous CAPs. These policy recommendations were presented to DG Agri in Brussels in October at a final high profile event in the European Parliament on November 29th.

Outputs

To complement the research outputs of AGFORWARD, a wide range of resources have been developed for students, farmers and policy makers. These include training tools for farmers, technicians and students, including reports, presentations, videos and booklets, hosted on www.train.agforward.eu. These will be added to in the final few months of the project. The ORC has produced a number of short films focusing on UK agroforesters including Iain Tolhurst, Alan Schofield, Ted Green and Wendy Seel, which can be found on-line at https://vimeo.com/channels/AGFORWARD

What next for agroforestry at ORC?

The AGFORWARD project has been a major project for the agroforestry team at ORC, and has opened up many new opportunities for on-going collaborations and new areas of research. The Agroforestry Innovations Network (AFINET) project which started in January 2017 is a great follow on to Agforward. AFINET is focused on making the outputs of research projects such as AGforward more accessible to farmers and other stakeholders. In the UK, we are working with the Farm Woodland Forum and have three on-farm agroforestry workshops planned for early 2018 (see back cover).

We also have a new project on using woodchip for soil fertility (See WOOFS p18)

In terms of research, the value of tree leaves as a fodder for livestock is a new theme that has been developed through AGFORWARD which has triggered a lot of interest and we would like to expand this in the future.

Acknowledgements

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References

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Harvesting tree fodder from an ash tree, June 2016

Box 1: Making the most of the space available – cropping the tree understorey

Planting trees into arable or vegetable fields means taking up to 20% of the land out of annual cropping. There may be no return from the trees for many years after planting; ranging from five years for top fruit and short rotation coppice to several decades for timber trees. In many agroforestry systems, the area between the trees and under the tree canopy is underutilised and unmanaged. This can create problems with weed control. One option is to plant alternative crops in the tree rows to provide an income in the years following tree establishment, or longer if shade tolerant species are used.

Working with organic grower Iain Tolhurst (Tolly) of Tolhurst Organic CIC, we compared the impact of different approaches to understorey management on economics and biodiversity (plants, including weeds, and invertebrates). Trees were planted in one field in March 2015 (see ORC Bulletin No.119 for more details), with a range of different crops established under the trees (Table 1).

Plant biodiversity, as measured by species richness, increased over time in the tree understorey in all rows with the exception of the long-term beetle bank, which was already well established at the time of tree planting and remained relatively stable in terms of species number and composition over the three-year monitoring period. The evenness of the species distribution in each of the tree rows increased over time, as the cover of the sown fertility building legumes (*Trifolium pratense* and *Trifolium repens*) declined while other unsown species appeared. Without management, grasses and other unsown species may start to dominate the understorey. For example, couch grass (*Elymus repens*) was seen to increase in the tree rows over time and this could potentially spread into the cropping areas and cause problems. Couch growth is more vigorous in the first year after tillage ceases. It is sensitive to shading and over time the amount of couch between the trees is likely to reduce as the cover increases; however it may still be a problem in the disturbed edges between the tree and the cropping areas.

Table 1: Description of understorey composition (T=Tree row)

Row	T1	T2	T3	T4	T5	T6
2015	Legume and herb mix planted July 2013	Long term beetle bank	Grass, vetch, red clover	Natural regeneration	Legume and herb mix planted July 2012	Legume and herb mix planted July 2012
2016	Legume and herb mix planted July 2013	Long term beetle bank	Grass, vetch, red clover	Rhubarb crowns planted Spring 2016	Daffodils and narcissi planted Dec 2015	Daffodils and narcissi planted Dec 2015
2017	Globe artichokes planted April 2017	Long term beetle bank	Herbaceous cut flowers planted May 2017	Rhubarb crowns – 25 plants replaced	Daffodils and narcissi	Daffodils and narcissi

Rhubarb in understorey at Tolhurst Organic

A large proportion of the establishment cost was for reinforced wire mesh cages to protect the apple trees from deer damage. This cost was covered by the charity supporting the initial tree planting, but may be a barrier that prevents other farmers from planting such systems where deer pressure is high. If markets can be established for the new crops then the addition of understorey crops makes the short term financial picture look better, spreading the risk and repaying the establishment costs within a 2-3 year period. These crops need to be chosen carefully for disease resistance and ability to compete with the existing vegetation. Over time, competition with both the understorey vegetation and the trees is likely to affect the viability of the understorey crop. Different crops may be more appropriate at a later stage or it may be that, as the system matures and a return on the trees is seen, there is no longer a need for understorey crops. The management implications of introducing new crops into an already diverse system should also be considered, particularly with regard to labour requirements, timing of harvesting and any ongoing maintenance.

Box 2: Establishing shade-tolerant swards in silvopoultry systems

It is well known that free-range poultry are more inclined to use the range when it is enriched with trees, and feather pecking is also reduced when more hens use the range. Thus, establishment of trees in the outdoor run is considered to improve hen welfare. However, an issue with existing poultry agroforestry systems identified by producers of the Sainsbury's Woodland Chicken Development Group is the lack of vegetation under the trees due to a closed canopy reducing light levels at the ground; and where trees have been pollarded to open up the canopy, weeds have established rather than grasses. The development of a shade-tolerant sward mixture that could establish and survive under the trees and also offer potential nutritional (and perhaps medicinal) benefits for the chickens was identified as a priority by the producers. We worked with Cotswold Seeds to develop three sward mixtures to compare, and trialled these mixtures in the silvopoultry experimental site at FAI Farms in Oxford. The mixtures were sown in replicated 15 year old mixed broadleaf plots and compared with a natural regeneration control. Mix 1 was a commercially available standard sward mixture for chicken enclosures, Mix 2 was a customised grass-only sward mixture with shade tolerant species and Mix 3 a diverse sward mixture including grasses, legumes and forage herbs. Chickens were excluded for the first three months to allow sward establishment and then introduced for a six week period at two densities and compared with control plots without chickens.

Findings from this trial demonstrated that establishing a sward under the trees is possible but the challenge is to maintain the sward in the presence of chickens. Optimising chicken pressure appears to be the key to maintaining a sward. Once the trees are thinned, commercially available seed mixtures can be sown to provide ground cover. This has economic implications for poultry keepers as the more specialised mixtures are likely to have higher seed prices as the seed is more expensive to source. Sward establishment rates increased one month after sowing for all mixtures, indicating higher weed suppression potential after four weeks and minimum growth time required for establishment. In order to develop systems that are beneficial for both farmers and chickens further research is needed into how to distribute the flock more evenly, therefore spreading the pressure across the range.

Trialling sward mixtures at FAI Farms, with and without chickens

Box 3: Tree fodder – food for thought

The value of tree leaves as livestock fodder is of increasing interest to farmers, as a buffer to climate change impacts on forage yields and quality. Within AGFORWARD we carried out a small pilot project to investigate the fodder value of some selected tree species on Elm Farm. Leaf samples were collected from Short Rotation Coppice (SRC) alder (*Alnus glutinosa*) and willow (*Salix viminalis*) in August 2015, and from ash (*Fraxinus excelsior*), goat willow (*Salix caprea*) and elm (*Ulmus minor)* trees on Elm Farm in June 2016. Leaf samples were taken from whole branches in both the SRC trees and standard trees; thus leaves were of varying ages. As part of a pilot study on the effect of air-drying tree fodder over winter and testing palatability, branches of the ash, goat willow and elm were bundled, tied and left to dry naturally in a covered barn from June to March. In March, leaf samples were taken from the air-dried bundles, before the bundles being fed to housed cattle and young stock (See video at https://vimeo.com/217077820).

Table 2. Chemical composition of tree leaves

Common name	Latin name	Date sampled	Dry Matter (%)	NDF (% DM)	ADF (% DM)	Lignin (% DM)	DOM (%)
Willow	*Salix viminalis*	Aug-15	33	37.29	22.12	11.33	55.29
Common alder	*Alnus glutinosa*	Aug-15	38	37.61	24.76	13.51	76.19
Ash	*Fraxinus excelsior*	Jun-16	39	29.59	14.84	5.02	85.68
Goat willow	*Salix caprea*	Jun-16	35	32.15	20.57	8.77	73.51
English elm	*Ulmus minor*	Jun-16	37	43.06	12.15	3.31	77.72

Digestible organic matter (DOM) varied between species, with lowest levels recorded for samples collected in August (Table 2). However, DOM of the other species was higher and compared favourably with typical livestock forages such as hay (47-67%), grass silage (52-67%) and grazed grass (64-75%).

The greatest potential for tree fodder, however, may be as a source of minerals, particularly to address deficiencies in feed or forage. Essential mineral elements are those which are known to have a metabolic function in animals or plants. Zinc is present in all animal tissue, organs and bones, playing an important role in growth, cell repair, hormones, enzyme activation, the immune system, and skin integrity. Zinc also plays a role in the optimum utilisation of nutrients and a deficiency can impair protein and carbohydrate metabolism. Willow is particularly high in zinc, with *Salix caprea* containing 144 mg/kg DM and *Salix viminalis* containing 245 mg/kg DM. The level of zinc in willow is substantially higher than those found in grass at 5 mg/kg DM, in silage at 25-30 mg/kg DM and in hay at 17-21 mg/kg DM. Levels of iron were notably high in the dried samples and in elm, in particular, at 258 mg/kg DM. Willow and alder contained substantially higher levels of manganese than other tree species. All the tested elements increased in the air-dried leaves compared to fresh leaves although where levels were low in the fresh samples, this increase was minimal. For example, phosphorus in elm was 2.3 g/kg DM fresh and only 2.4 g/kg DM air-dried. Levels of phosphorus (an essential component of the skeleton) were highest in the dried goat willow (5.5 g/kg DM) but all trees compare favourably with grass at 2.8-3.5 g/kg DM, silage at 2.0-4.0 g/kg DM and hay at 1.5-3.5 g/kg DM.

Feeding air-dried tree fodder to cattle and youngstock at Elm Farm

The results of mineral analysis in this study add to the existing body of knowledge which is being compiled in an online database (http://www.voederbomen.nl/nutritionalvalues/). However, differences in mineral content between species, between fresh and dried samples and between seasons indicate that the value of tree fodder can be better understood with further analysis. The high levels of minerals in tree fodder suggest that trees can offer an alternative source of mineral supplementation. The higher levels in dried samples, compared to fresh, suggest that there is further scope to extend the value of minerals in tree fodder beyond the growing season.

Box 4: Developing agroforestry-adapted cereals at Wakelyns Agroforestry

Growing trees and cereals in close proximity to each other, as in alley-cropping systems, means that the two components may compete with each other for resources such as water, light and nutrients; in such situations, cereal yields may be lower, particularly in the alley edge zone, adjacent to the trees. The development of arable crops specifically adapted for agroforestry systems was identified as an innovation for further development at the UK silvoarable stakeholder workshop. Evolutionary plant breeding can be used to develop varieties that are particularly well adapted to growing in close proximity to trees. The principle is to let natural selection act on these diverse crop populations to select the plants that are best suited to the prevailing conditions i.e. develop an 'alley-edge' population and an 'alley-centre' population.

At Wakelyns Agroforestry in Suffolk, a replicated cross-over experiment aimed to compare performance of selected material in each environment based on the hypothesis that wheat lines will perform best in the environment from which they were selected (i.e. 'alley-edge' selected lines will perform better in the 'alley-edge' plots than 'alley-centre' lines). A spring wheat composite cross population (CCP) was grown in plots across the willow system agroforestry alley in 2014. Plots of bulk CCP were selected and harvested separately from plots on either side of the alley, adjacent to the tree rows (East of Trees (EOT), West of Trees (WOT)) and the Centre of Alley (COA). In spring 2015, plots measuring 1.2m by 10.2m were drilled in a replicated cross-over trial (i.e. where plants selected from each alley location in 2014 were grown in each of the three alley locations in 2015 in three blocks) in a hazel Short Rotation Coppice (SRC) agroforestry system.

In 2015, wheat yields ranged between 0.90 and 3.99 t/ha (@15% moisture content); hectolitre weights between 367.83g and 383.79g (@15% m.c) and thousand grain weights between 42.90 and 50.48g (@15% m.c.). There was a significant effect of location on yield and hectolitre weight, but not on TGW. Yields and hectolitre weights were significantly higher in the centre of the alley than at either edge (Figure 1). There were no significant differences between the different selections (EOT, COA and WOT) for any of the yield parameters, and no significant interactions between the selections and their locations. This suggests that in 2015, there was no adaptation of selected populations to their selected locations (i.e. EOT populations do not perform any better in the EOT locations than in the other locations).

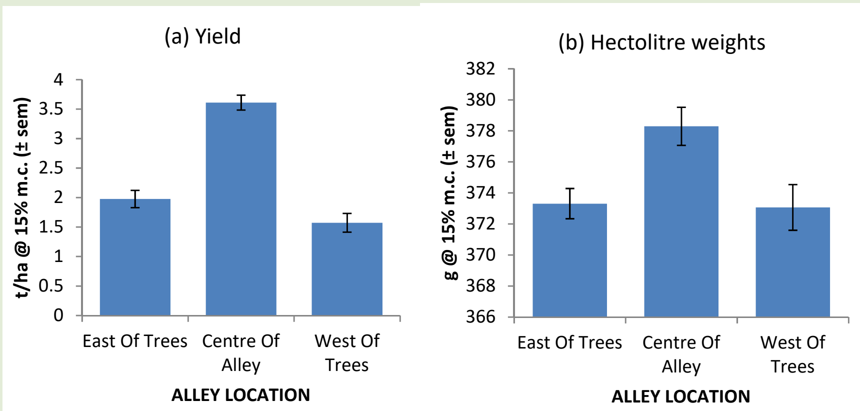

Figure 1: (a) The mean grain yield and (b) hectolitre weights of a composite cross population (YQCCP) in three positions across a ten metre wide alley in 2015

In 2016, in contrast, some differences emerged when looking at the yield of the three populations. The same trial design as in 2015 was sown in a different alley between two willow rows, one of which had previously been coppiced. Yields ranged between 0.7 and 2.2 t/ha, with the EOT bed (alongside the coppiced willows) yielding 30% more the other positions combined (results not shown). This contrasts with the 2015 results where the central alley location yielded highest (Figure 1) and is probably due to lower competition for light in the EOT bed compared to the standing tree row on the other side. As far as the three selections are concerned, while there were no significant differences between the selections from the centre of the alley vs. the selections at the two edges, between these latter, the EOT selection yielded 35% more than WOT selection, regardless of the location (Figure 2). No significant interaction between alley location and selection was found. In conclusion, these results suggest that a population reproduced on the eastern side of a tree row for two seasons can becomes more productive than the same population reproduced in other positions in the alley. Whether this is because of natural selection due to differential environmental pressure across the alley, resulting in an advantage for the EOT position, or because conditions in the WOT (e.g. persistence of high humidity) results in less healthy seeds is not clear, but the reasons are worth investigating.

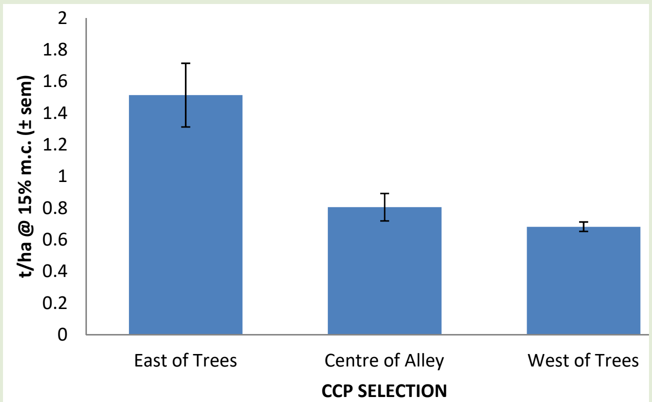

Figure 2: Spring wheat grain yield of the YQCCP population selected in the East of Trees, Centre of Alley and West of Trees positions in 2016.